

PHYSICOCHEMICAL EVALUATION

Physicochemical data were collected at all seven sampling locations between November 9 and November 17, 1981 during a period of low flow. A total of 58 parameters were analyzed for each station (Table 4). The data indicate that the streams in the basin are highly buffered, hardwater streams. Alkalinity, hardness, and pH concentrations were within the range expected for buffered, alkaline streams of the Blue Grass physiographic region when compared with Division of Water (DOW) ambient water quality data (STORET 1979-1981). In comparison with other SUD sampling sites, elevated DO and pH values were noted at 26-1, 28-2, and 28-3, partially the result of the presence of dense growths of attached algae at those sites, a phenomenon also noted by Warren (1971). Kentucky Surface Water Standards (KSWS) (401 KAR 5:031, Section 4 (1)(b)) were violated at station 26-1 (Chenoweth Run), where pH values exceeded 9.0 at the time of sampling. Values for conductivity, total dissolved solids (TDS), and chloride (Cl^-) were somewhat elevated throughout the drainage. Total dissolved solids often influence aquatic biological communities through osmotic diffusion mechanisms and changes in the supply of nutrients and other important materials (Reid and Wood 1976).

A total of 103 WWTP point source discharges are present in the Floyds Fork drainage (Table 1) (DOW WLA files). The introduction of WWTP effluents to streams has been shown to result in elevated levels of Cl^- (Hynes 1974, APHA 1981), fluoride (F^-) (Holdren et al. 1981), sulfate (SO_4^{--}) (Olive and Smith 1975) and nutrients (Mackenthun 1965, Hynes 1974, APHA 1981). Values for those parameters were elevated at sites in the vicinity of metropolitan Louisville (25-1, 25-2, 26-1) where the greatest impacts from WWTPs occur. Those parameters generally exhibited lower values at the upstream sites (segment 28), which is more sparsely populated.

Table 4: Physicochemical Data for
the Floyds Fork System

Parameter	Stations						
	25-1	25-2	26-1	27-1	28-1	28-2	28-3
Conductivity (umhos/cm @ 25°C)	535	514	598	521	431	511	628
pH	7.4	7.7	9.2	7.8	7.4	8.2	8.2
Air temperature (°C)	13	8	8	8	8	10.5	10
Water temperature (°C)	9	9	9	9	7.5	8	7
Turbidity (NTU)	7.8	3.5	2.2	5.4	5.0	1.5	ND
DO (mg/l)	6.9	12.0	120.0	9.8	3.9	11.6	10.8
Acidity (mg/l)	12.2	0	1.8	6.0	16.0	16.0	10.0
Alkalinity (mg/l)	187.8	175	114.0	200.0	232.2	234.4	243.4
BOD ₅ (mg/l)	2.3	0.4	0.5	0.8	2.5	1.6	2.0
Chloride (mg/l)	26.3	33.4	57.7	21.7	8.8	20.6	29.1
COD (mg/l)	21.1	22.1	16.9	18.7	22.5	17.2	18.8
CN (free) (mg/l)	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01
Total Dissolved Solids (mg/l)	376	328	402	350	310	336	426
Fluoride (mg/l)	0.34	0.62	1.17	0.17	0.15	0.19	0.16
Total Hardness (mg/l)	231.2	219.4	194.2	271.6	240.4	262.2	320.2
Sulfide (mg/l)	0.3	K0.1	K0.1	0.3	0.2	0.3	K0.1
Phenols (mg/l)	K0.1	K0.1	K0.1	K0.1	K0.1	K0.1	K0.1
Sulfate (mg/l)	73.7	70.0	100	80.1	15.3	58.6	90.7
Suspended Solids (mg/l)	12	3	8	3	9	4	3
NH ₃ -N (mg/l)	0.25	0.25	0.11	0.22	0.11	0.15	0.25
NO ₂ + NO ₃ - N (mg/l)	0.520	2.40	9.40	0.120	0.135	0.175	0.015
TKN (mg/l)	0.86	1.21	0.85	0.65	0.58	0.65	0.84
Phosphorous (total) (mg/l)	0.890	1.60	1.44	0.095	0.115	0.226	0.151
Ortho-P	ND	ND	ND	ND	ND	ND	ND
Phthalate Esters (ug/l)	K5	111	5	K5	K5	K5	K5
Benzyl butyl phthalate (ug/l)	K1	11	5	K1	K1	K1	K1
Bis (2-ethylhexyl) phthalate (ug/l)	K1	25	K1	K1	K1	K1	K1
Di-n-butyl phthalate (ug/l)	K1	18	K1	K1	K1	K1	K1
Di-ethyl phthalate (ug/l)	K1	57	K1	K1	K1	K1	K1
Di-methyl phthalate (ug/l)	K1	K1	K1	K1	K1	K1	K1
Al (total) (ug/l)	400	530	80	430	210	80	110
As (total) (ug/l)	6	2	3	2	6	2	2
Ba (total) (ug/l)	42	90	40	57	56	35	111
Be (total) (ug/l)	K1	K1	K1	K1	K1	K1	K1
Cd (total) (ug/l)	2	20	8	9	26	12	3
Ca (total) (mg/l)	59	56	45	61	60	61	74
Cr (total) (ug/l)	3	3	1	1	1	2	1
Cu (total) (ug/l)	7	14	8	6	6	4	6
Fe (total) (ug/l)	268	142	54	44	296	50	50
Pb (total) (ug/l)	18	502	108	220	368	166	15
Mg (total) (mg/l)	19.2	17.5	16.4	20.0	18.2	20.2	23.0
Mn (total) (ug/l)	62	18	6	41	124	10	12
Hg (total) (ug/l)	0.4	0.5	0.3	0.4	0.4	0.4	0.4
Ni (total) (ug/l)	15	24	10	21	15	12	18
K (total) (mg/l)	8.05	8.60	24.0	4.00	6.70	5.60	6.20
Se (total) (ug/l)	K1.0	K1.0	K1.0	1.1	K1.0	K1.0	K1.0
Ag (total) (ug/l)	K1	K1	K1	K1	K1	1	K1
Na (total) (mg/l)	25.0	28.5	44.0	14.5	3.70	3.45	17.5
Zn (total) (ug/l)	20	26	28	8	20	10	18
Al (dissolved) (ug/l)	100	200	44	64	56	33	100
Cd (dissolved) (ug/l)	2	6	8	18	10	11	2
Cr (dissolved) (ug/l)	1	2	1	2	1	1	1
Cu (dissolved) (ug/l)	4	6	8	4	6	3	5
Fe (dissolved) (ug/l)	58	46	36	36	102	32	20
Pb (dissolved) (ug/l)	7	36	164	144	78	170	8
Mn (dissolved) (ug/l)	50	16	4	22	117	8	11
Hg (dissolved) (ug/l)	0.3	0.3	0.4	0.4	0.7	0.6	0.3
Se (dissolved) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0

K - below detection limit listed

ND - not determined

*L - above detection limit listed

Nutrient concentrations (nitrite + nitrate-nitrogen ($\text{NO}_2 + \text{NO}_3\text{-N}$) and total phosphorus (TP) were elevated at Chenoweth Run and downstream stations (segment 25) on Floyds Fork. Observed $\text{NO}_2 + \text{NO}_3\text{-N}$ values at stations 26-1 and 25-2 exceeded the mean STORET values for this parameter, while TP concentrations at stations 25-1, 25-2, 26-1 and 28-2 were in excess of the mean STORET TP value. Ammonia-nitrogen ($\text{NH}_3\text{-N}$) values were low at all sites (0.11 to 0.25 mg/l) and unionized ammonia concentrations did not violate KSWS at any station. Total phosphorous concentrations in flowing waters are generally below 0.1 mg/l (National Technical Advisory Committee 1968, Keup 1968), except in streams receiving agricultural runoff (Omernik 1977) and WWTP effluents (Wetzel 1975). Stations 25-1, 25-2 and 26-1 substantially exceeded that value, while stations in segment 28 were only slightly in excess of 0.1 mg/l.

Kentucky Surface Water Standards (401 KAR 5:031, Section 4 (1)(I)(4) for phthalate esters were violated at two sites in the vicinity of metropolitan Louisville (25-2, 26-1). Phthlate esters are a group of chemicals used as plasticizers, primarily for the production of polyvinyl chloride resins. Levels are generally higher in the vicinity of industrial centers (Hites 1973, U.S. EPA 1980a).

Values for total mercury (Hg) violated KSWS (401 KAR 5:031, Section 4 (1)(I)(4 and exceeded the EPA recommended chronic protection criterion (U.S. EPA 1980b) at all sites. Total cadmium (Cd) violated Kentucky standards at two sites (25-2, 28-1) and U.S. EPA acute protection levels at five sites (25-2, 26-1, 27-1, 28-1, 28-2). Water column concentrations of total Hg, Cd and lead (Pb) exceeded criteria (U.S. EPA 1980b, c, d) for aquatic life protection at several sites, particularly in segment 25.

Sediment samples were collected at three sites (25-1, 26-1 and 28-2). A total of 28 parameters were analyzed for each sample (Table 5). The results were

**Table 5: Sediment Data for the
Floyds Fork System**

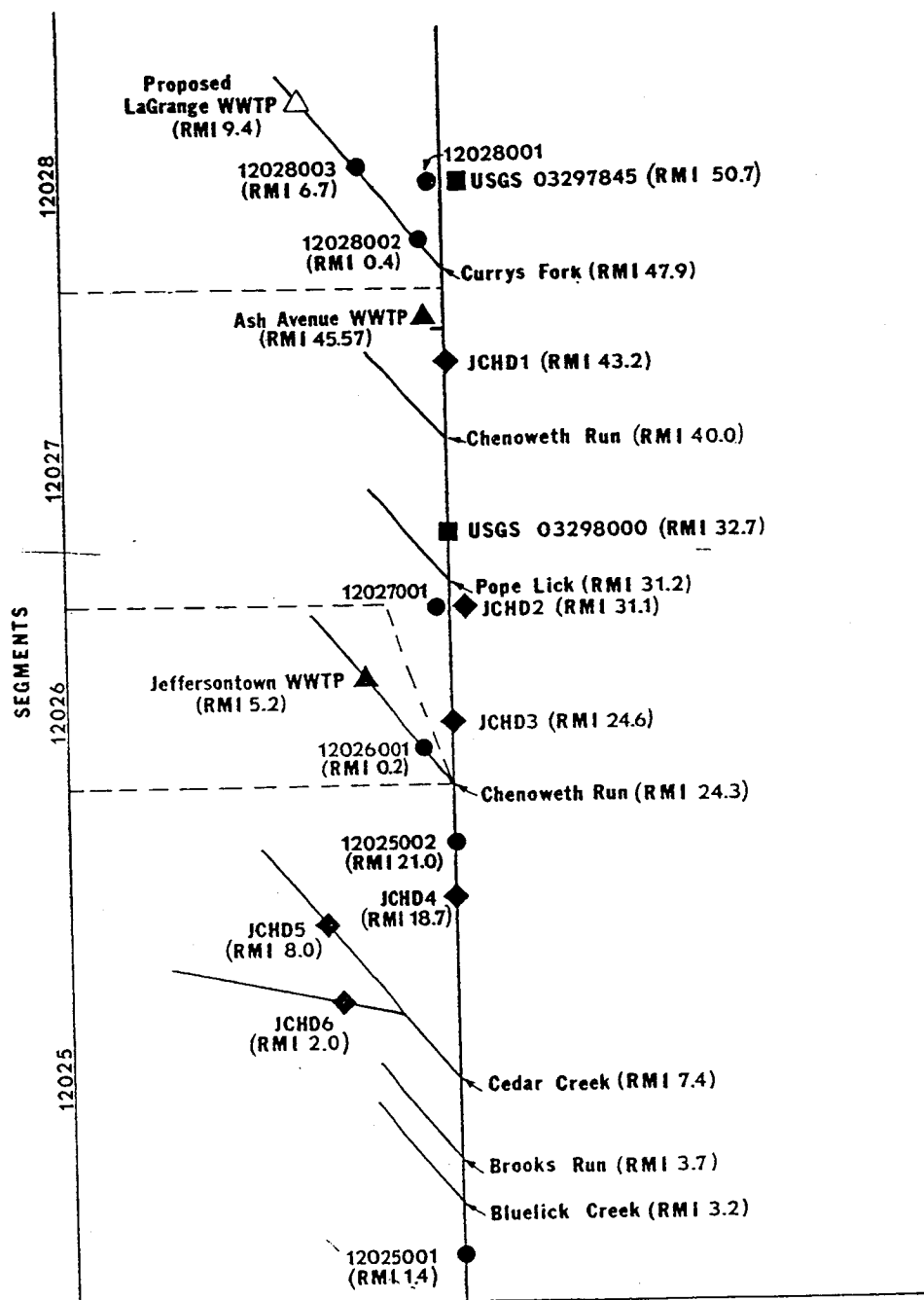
Parameter	Stations		
	25-1	26-1	28-2
PCB's, (ug/kg)	K100.0	K100.0	K100.0
Aldrin, (ug/kg)	K5.0	K5.0	K10.0
Dieldrin, (ug/kg)	K2.0	K2.0	K2.0
DDT, total, (ug/kg)	K0.02	K0.02	K0.02
O,P'DDE, (ug/kg)	K2.0	K2.0	K2.0
P,P'DDE, (ug/kg)	K2.0	K2.0	K2.0
O,P'DDD, (ug/kg)	K4.0	K4.0	K4.0
P,P'DDD, (ug/kg)	K4.0	K4.0	K4.0
O,P'DDT, (ug/kg)	K4.0	K4.0	K4.0
P,P'DDT, (ug/kg)	K4.0	K4.0	K4.0
Chlordane, (ug/kg)	K2.0	41.0	K2.0
Cis Isomer (Chlordane) (ug/kg)	K2.0	23.0	K2.0
Trans Isomer (Chlordane) (ug/kg)	K2.0	10.0	K2.0
Trans Isomer (nonachlor) (ug/kg)	K2.0	8.0	K2.0
Endrin, (ug/kg)	K2.0	K2.0	K2.0
Methoxychlor, (ug/kg)	K10.0	K10.0	K10.0
Hexachlorobenzene, (ug/kg)	K10.0	K10.0	K10.0
Pentachlorophenol, (ug/kg)	2.2	14.0	2.1
Hexachlorocyclohexane, alpha BHC, (ug/kg)	K10.0	K10.0	K10.0
gamma BMC (Lindane) (ug/kg)	K10.0	K10.0	K10.0
Toxaphene, (ug/kg)	K100.0	K100.0	K100.0
Arsenic, total, (mg/kg)	34.1	31.8	55.2
Cadmium, total, (mg/kg)	3.0	2.9	3.8
Chromium, total, (mg/kg)	60.0	42.4	38.2
Copper, total, (mg/kg)	15.5	26.6	23.9
Mercury, total, (mg/kg)	0.082	0.14	0.084
Lead, total, (mg/kg)	54.4	81.0	65.8
Zinc, total, (mg/kg)	73.5	103.0	70.7

K - below detection limit listed

compared with U.S. EPA guidelines (U. S. EPA 1977). Detectable quantities of chlordane and pentachlorophenol (PCP) were noted in sediments at station 26-1. Chlordane has been extensively used for termite control as well as an agricultural insecticide. Pentachlorophenol is used primarily for the preservation of wood and wood products. Sediment concentrations of other organic compounds were below detection limits. Considerable quantities of certain heavy metals, notably arsenic (As) and Pb, were found in sediments at all three sites sampled. Lead in sediment and water column samples is related to elevated levels of this metal in the air surrounding the metropolitan Louisville area. The Kentucky Division of Air Pollution Control (KDAPC) has documented this problem, which is attributable to automotive exhaust (Van Hassel et al. 1980), for over eight years. The problem was most severe approximately five years ago and has been improving since then (KDAPC unpublished data).

A considerable amount of historical physicochemical data has been collected at various sites in the Floyds Fork system. The locations of these sites in relationship to the SUD stations are detailed in Figure 2. The USGS maintains two water quality monitoring stations on Floyds Fork. Data have been published since 1950 for one site and since 1979 for the other site. The Louisville and Jefferson County Department of Public Health (JCHD) has sampled four sites on Floyds Fork and two sites on tributaries (Cedar Creek and Pennsylvania Run) since 1975. Site descriptions are presented in Table 6 while parameters analyzed and a summary of the data are presented in Tables 7 and 8. All parameters were analyzed by Standard Methods (APHA 1981). A monitoring program was established during the fall of 1981 by the Water Quality Advisory Board (WQAB) at various sites in the county, including two sites on Floyds Fork. Water samples were analyzed by JCHD and the results were reported for the first year of sampling (WQAB no date).

Figure 2: Physicochemical Sampling Stations for SUD USGS and JCHP



**Table 6: Physicochemical Sampling Locations of Stations Collected
by Louisville & Jefferson County Department of Public Health (1975-1982)**

<u>Station</u>	<u>Stream</u>	MP	<u>Specific Location</u>
JCHD1	Floyds Fork	43.2	Aiken Road Bridge
JCHD2	Floyds Fork	31.1	Pope Lick Road
JCHD3	Floyds Fork	24.6	Seatonville Road Bridge
JCHD4	Floyds Fork	18.7	Bardstown Road Bridge
JCHD5	Cedar Creek	8.0	Thixton Road
JCHD6	Pennsylvania Run	2.0	Jefferson/Bullitt County Line

**Table 7: Summary of Physicochemical Data (1975–1982)
collected by Louisville and Jefferson County Department of Public Health**

<u>Parameter</u>	<u>Mean Values (Number of Observations)</u>					
	<u>Station</u>					
	<u>JCHD1</u>	<u>JCHD2</u>	<u>JCHD3</u>	<u>JCHD4</u>	<u>JCHD5</u>	<u>JCHD6</u>
TSS (mg/l)	56 (62)	48 (62)	30 (61)	59 (61)	26 (59)	17 (59)
TDS (mg/l)	256 (15)	266 (15)	326 (14)	264 (14)	292 (14)	234 (14)
NO ₃ +NO ₂ (mg/l)	2.485 (54)	1.923 (55)	5.502 (54)	3.233 (56)	5.22 (53)	4.30 (56)
PO ₄ (mg/l)	0.961 (53)	0.764 (53)	2.241 (55)	0.847 (55)	1.54 (55)	0.80 (54)
pH	7.2 (71)	7.3 (72)	7.4 (74)	7.3 (72)	7.4 (67)	7.3 (70)
DO (mg/l)	8.2 (89)	8.8 (89)	10.9 (87)	9.0 (88)	10.0 (85)	8.7 (88)
BOD ₅ (mg/l)	3.291 (89)	2.830 (90)	3.256 (88)	2.477 (88)	2.30 (87)	2.80 (87)
Zn (µg/l)	K46 (17)	K26 (17)	K77 (17)	88 (17)	K18 (17)	K89 (17)
Cr (µg/l)	K12 (15)	K28 (17)	K24 (16)	K19 (14)	K21 (15)	K17 (15)
Cd (µg/l)	K14 (14)	K15 (14)	K17 (13)	K17 (17)	K17 (17)	K16 (14)
Cu (µg/l)	K54 (16)	K31 (17)	K133 (17)	K115 (17)	K18 (17)	K92 (17)
Ni (µg/l)	K53 (17)	K29 (17)	K93 (17)	K59 (17)	K25 (17)	K33 (17)
Pb (µg/l)	K72 (17)	K32 (17)	K164 (17)	K104 (17)	K40 (17)	K55 (17)
Fe (µg/l)	372 (17)	331 (17)	531 (17)	249 (17)	223 (17)	474 (17)
Mn (µg/l)	149 (17)	58 (17)	208 (17)	52 (17)	39 (17)	53 (17)

K - less than value listed

Table 8: Summary of Physicochemical Data (1975-1982)
collected by Louisville and Jefferson County Department of Public Health

Maximum Value/Minimum Value

Station

<u>Parameter</u>	<u>JCHD1</u>	<u>JCHD2</u>	<u>JCHD3</u>	<u>JCHD4</u>	<u>JCHD5</u>	<u>JCHD6</u>
TSS (mg/l)	308/0	808/1	492/0	864/2	256/0	160/0
TDS (mg/l)	449/125	381/0	541/184	400/44	542/51	384/107
NO ₃ +NO ₂ (mg/l)	9.074/0.085	9.694/0.010	19.101/0.570	9.524/0.115	18.84/0.17	14.88/0.14
PO ₄ (mg/l)	3.000/0	4.000/0	6.428/0.214	2.570/0.071	3.428/0.285	2.350/0.057
pH	8.4/6.5	8.4/6.4	8.9/6.3	8.4/6.4	8.8/6.4	9.1/6.4
DO (mg/l)	15.0/1.5	15.4/2.6	20.0/4.5	20.0/3.8	17.8/4.8	14.6/3.1
BOD ₅ (mg/l)	7.16/0.70	8.85/0.44	13.600/0.300	6.350/0	7.76/0	8.51/0.15
Zn (µg/l)	110/K10	33/K10	250/K10	250/20	90/K10	1000/K10
Cr (µg/l)	30/K10	90/K10	70/K10	70/K10	70/K10	90/K10
Cd (µg/l)	30/K10	40/K10	40/K10	50/K10	50/K10	50/K10
Cu (µg/l)	150/K10	120/K10	1250/K10	470/K10	50/K10	1000/K10
Ni (µg/l)	290/K10	190/K10	750/K10	250/K10	60/K10	100/K10
Pb (µg/l)	420/K10	120/K10	2180/K10	830/K10	210/K10	330/K10
Fe (µg/l)	1570/10	1150/10	4630/30	870/40	1630/10	600/K10
Mn (µg/l)	813/10	150/20	2410/10	130/20	90/10	140/10

K - below detection limit listed

The historical data were compared with values observed during the SUD survey. While TDS levels were similar, mean total suspended solids (TSS) concentrations reported by JCHD and USGS were considerably higher than observed in the present study. Comparable differences were noted for nutrients and total metals, because the historical data reflected seasonal and hydrological variations. The maximum and minimum values observed for selected parameters at each JCHD site are presented in Table 8. Those data are thought to be more characteristic of the physicochemical quality of Floyds Fork. Since many SUD values for various parameters were close to minimum values observed by JCHD and USGS, it is felt that the SUD physicochemical data presented in this report reflect better than average water quality conditions during the sampling period.

An examination of JCHD maximum/minimum data (Table 8) reveals periodic violations of KSWs (401 KAR 5:031). Violation of the KSWs for DO (401 KAR 5:031, Section 4, (1)(e)(1)) occurred ten times at JCHD1, four times at JCHD2 and JCHD6, and one time at JCHD4. Maximum Cd values observed at all sites were in violation of 401 KAR 5:031, Section 4, (1)(l)(4). Total iron (Fe) violated KSWs (401 KAR 5:031, Section 4 (1)(h)(3)) at JCHD1, JCHD2, JCHD3 and JCHD5. Maximum total copper (Cu) values observed for exceeded U.S. EPA (1980e) acute protection criteria at all sites. Total zinc (Zn) exceeded U.S. EPA (1980f) chronic protection criteria at all sites except JCHD2. Total Pb exceeded U.S. EPA (1980d) acute protection criteria at JCHD1, JCHD3 and JCHD4 and exceeded chronic protection criteria at all sites. Total nickel (Ni) exceeded U.S. EPA (1980g) chronic protection criteria at JCHD1, JCHD2, JCHD3 and JCHD4.

The USGS maintains two water quality monitoring stations on Floyds Fork (Figure 2). USGS station 03297845 (Floyds Fork near Crestwood, KY) is located at the same site as SUD station 28-1, while USGS station 03298000 (Floyds Fork at Fisherville, KY) is located approximately 1.8 miles upstream from SUD

station 27-1. Recent data are available for both sites (USGS 1979, 1980, 1981, 1982), while earlier data (1950-53) are limited to the Fisherville site (Lamar and Laird 1953). Additional physicochemical data (1981-82) were collected at the Fisherville site by the Water Quality Advisory Board (WQAB no date).

Data from the Fisherville site indicate that average Fe, Cl^- , $\text{SO}_4^{=}$, TDS and conductivity levels have increased during the past 30 years, while pH, F^- and total hardness have remained relatively constant. The minimum values observed for turbidity, $\text{NO}_2+\text{NO}_3\text{-N}$, TP, Fe, Mn and Zn at the USGS station during 1982 exceeded levels for these parameters at 27-1. In contrast, values for conductivity, hardness, Cl^- , Cd, Pb and Ni were higher at 27-1 than the maximum concentrations seen at the USGS station during 1982. The USGS data revealed two violations of KSWs for Fe in 1982, while WQAB data indicated a Cd violation (41 ug/l) in December, 1981.

A comparison of USGS (03297845) data (1979-82) with SUD values at station 28-1 indicates that concentrations of many parameters at 28-1 were consistent with reported USGS mean values. However, values for As, Cd and Pb at 28-1 were considerably higher than maximum values observed by USGS, while Fe, Mn, Zn, Cr, Cu, phenols, $\text{SO}_4^{=}$, DO and nutrients at 28-1 were less than mean USGS values at this site. A review of the USGS data reveals two KSWs violations of DO standards, as well as two Fe violations. The maximum values observed for Fe and Mn were 31,000 ug/l and 1600 ug/l, respectively (June, 1982). Detectable quantities (2.2 ug/l) of 2,4-D, a phenoxy herbicide, were noted (May, 1980), although values for other organic compounds were below detection limits. This level of 2,4-D does not appear to be acutely toxic to aquatic life (Johnson and Finley 1980).

Floyds Fork

Station 25-1

Physicochemical data indicate that this station is impacted by upstream point and nonpoint source dischargers. Values for conductivity, Cl^- , TDS, $\text{SO}_4^{=}$ and TP were generally elevated with respect to upstream sites (segments 27, 28), as well as DOW ambient water quality data (STORET 1979-1981). The introduction of WWTP effluents to streams has been shown to result in elevated concentrations of Cl^- (Hynes 1974, APHA 1981), $\text{SO}_4^{=}$ (Olive and Smith 1975) and TP (Mackenthun 1965, Hynes 1974, APHA 1981). Values for $\text{NO}_2+\text{NO}_3\text{-N}$ were elevated with respect to headwater stations. Despite the presence of 52 point source dischargers with a combined design discharge in excess of 4 MGD, nutrient values were less than those observed at 25-2 and 26-1. Most of these small WWTPs discharge to tributaries of Floyds Fork (notably Brooks Run and Cedar Creek). Physicochemical data collected by JCHD on Cedar Creek and Pennsylvania Run, a tributary to Cedar Creek, are summarized in Tables 7 and 8. Nutrients are apparently being used by primary producers (algae) in these streams before entering Floyds Fork. McNeely Lake, a 53 acre hypereutrophic reservoir on Pennsylvania Run (DOW 1982), is functionally a large "polishing lagoon" for WWTPs in the Pennsylvania Run watershed.

Kentucky Surface Water Standards were violated for undissociated hydrogen sulfide (H_2S) and Hg. Chronic protection criteria for Cd (U.S. EPA 1980c) were exceeded. Phthalate esters, which were elevated at the upstream site 25-2, returned to background levels (below detection limits). Water column values for Pb were dramatically reduced from those observed at upstream sites and approached background levels (e.g. 28-3).

The sediments were heavily polluted with As and moderately polluted with Cr, Pb and Zn (U.S. EPA 1977). Detectable quantities of PCP were present in

the sediments. Values for other organic compounds were below detection limits. The presence of a large industrial landfill in the upstream watershed has the potential to contribute to excessive accumulation of metals and organic compounds in the sediments.

Floyds Fork

Station 25-2

This site is impacted by upstream point source dischargers, particularly those in the Chenoweth Run watershed (segment 26). Values for conductivity, Cl^- , F^- , $\text{SO}_4^{=}$ and nutrients were elevated with respect to other sites on Floyds Fork (Table 4), as well as historical data. The association between WWTP effluents and elevated concentrations of Cl^- , $\text{SO}_4^{=}$, and TP has been discussed previously. Fluoride levels are elevated in streams impacted by WWTP effluents, because F^- is added to drinking water at concentrations much higher than background levels (Holdren et al. 1981). Total phosphorous levels were the highest observed in this survey (1.6 mg/l), while $\text{NO}_2+\text{NO}_3\text{-N}$ exceeded 2 mg/l, which is typical of nutrient enriched streams (refer to Patrick 1950). This is most likely a result of point source dischargers in the upstream watershed. The high levels of nutrients have stimulated dense nuisance growths of filamentous algae. This, at least partially, accounts for the elevated DO concentrations noted at the time of sampling (early afternoon). Total Kjeldahl Nitrogen (TKN) values were the highest observed in this survey. Comparison of nutrient data from this study with historical JCHD data (stations JCHD3 & JCHD4) indicates that average nutrient values over a seven year period were higher than those observed in the present study (Table 7). Mean $\text{NO}_2+\text{NO}_3\text{-N}$ and TP concentrations at JCHD3 (3.6 miles upstream) were 5.5 mg/l and 3.2 mg/l respectively, approximately twice that observed at 25-2. Dissolved oxygen and pH values were somewhat higher than mean values noted at JCHD3 and JCHD4, but were within the range reported for these stations.

Kentucky Surface Water Standards were violated for phthalate esters, Cd and Hg. Values observed for Cd and Pb exceeded acute levels for the protection of aquatic life (U.S. EPA 1980c, d). Values for Pb were the highest observed in this survey. With the exception of Cd and Pb, JCHD metals data (seven year means) exceeded values observed in the present study. The Cd value noted at this site was similar to that seen at JCHD3 and JCHD4. The value observed for Pb (502 ug/l) was over three times the mean concentration at JCHD3 and JCHD4; however, maximum values at these latter sites were 2,180 ug/l and 830 ug/l, respectively. Additional data (WQAB no date) collected at the same site as JCHD4 indicated a Zn value (700 ug/l) in excess of recommended acute protection criterion for aquatic life (EPA 1980f).

Chenoweth Run

Station 26-1

The physicochemical data indicate that this site is affected by point and nonpoint source impacts occurring in this largely metropolitan watershed. Values for pH, Cl^- , F^- , $\text{SO}_4^{=}$ and $\text{NO}_2+\text{NO}_3\text{-N}$ were the highest observed in this survey (Table 4). Elevated values were noted for conductivity, TDS and TP. The association between WWTP effluents and elevated levels of Cl^- , $\text{SO}_4^{=}$, F^- , and nutrients has been discussed previously (Station 25-1). The JCHD unpublished data collected at this site indicated that average values for $\text{NO}_2+\text{NO}_3\text{-N}$, TP, and TDS have increased since 1975. A similar increase was observed for DO and pH. The high level of nutrients has stimulated dense, nuisance growths of attached algae which partially account for the elevated DO (> 20 mg/l) and pH (9.2) values noted at the time of sampling (late morning). Values for pH in excess of 9.0 are in violation of KWSW. It seems likely that downstream nutrient enrichment problems originate from this severely impacted stream.

Kentucky Surface Water Standards were violated for phthalate esters and Hg. Values observed for Cd exceeded acute protection criteria, while Pb exceeded chronic protection criteria for aquatic life (U.S. EPA 1980d).

The sediments were heavily polluted with As and Pb and moderately polluted with Cd, Cr, Cu and Zn (U.S. EPA 1977). Detectable quantities of chlordane (41.0 ug/l) and PCP (14.0 ug/l) were observed. Chlordane concentrations were below detection limits at the other two sites where sediments were collected. Sediment concentrations of PCP were nearly seven times greater at 26-1 than observed at the other two sites. Values for other organic compounds were below detection limits.

Floyds Fork

Station 27-1

This station is affected by point and nonpoint source impacts from both Pope Lick Creek and "lesser" Chenoweth Run, a different stream from that discussed at station 26-1. Station 27-1 is located at the same location as JCHD2. Values for conductivity, TDS and $\text{SO}_4^{=}$ were elevated with reference to some other SUD stations. Nutrient values were among the lowest seen in this survey; however, the concentrations observed in the present study seem to represent minimum values as reflected by historical physicochemical data (JCHD2) (Table 8). Mean values for $\text{NO}_2+\text{NO}_3\text{-N}$ and TP were sixteen and eight times greater, respectively, than were observed during the SUD survey. Maximum values at JCHD2 were similar to other Floyds Fork JCHD sites. The minimum $\text{NO}_2+\text{NO}_3\text{-N}$ and TP values noted by USGS at Fisherville (03298000) (1.7 miles upstream) (Figure 5) exceeded levels observed during the SUD sampling.

Kentucky Surface Water Standards were violated for undissociated hydrogen sulfide and Hg. Phthalate esters were below detection limits. Values observed for Cd exceeded U.S. EPA recommended acute protection criteria levels

(U.S. EPA 1980c), while Pb exceeded chronic protection criteria levels for aquatic life (U.S. EPA 1980d). With the exception of Pb (220 ug/l), values for metals were either similar to or lower than mean values observed by JCHD. However, minimum USGS values for Fe, Mn and Zn during 1982 exceeded levels observed in the SUD survey. Two violations of KSWs for Fe were noted at the USGS Fisherville site, while WQAB data at this location indicated a Cd violation (41 mg/l) in December, 1981.

Floyds Fork

Station 28-1

This site is primarily affected by non-point source impacts, largely agricultural in nature. An oil sheen was noted on the stream surface at the time of sampling. Values observed for conductivity, pH, Cl^- , TDS, F^- and $\text{SO}_4^{=}$ were the lowest observed in this survey. These values were similar to mean concentrations of these parameters observed by USGS (03297845, same site as 28-1) since 1979. Nutrient concentrations were also low, particularly compared to downstream SUD segments. Average USGS values for $\text{NH}_3\text{-N}$ and TP were similar to SUD values, while the $\text{NO}_2\text{+NO}_3\text{-N}$ concentration at 28-1 was considerably less than USGS mean levels. Mean nutrient concentrations at JCHD1 (7.2 miles downstream) were considerably higher. As was the case at previous sites, $\text{NO}_2\text{+NO}_3\text{-N}$ and TP levels approached the minimum values observed at JCHD1. However, the presence of 17 small WWTPs between 28-1 and JCHD1 may account for the higher average nutrient concentrations at the latter station. Dissolved oxygen concentrations were low (3.9 mg/l) at the time of sampling (late morning) and were in violation of KSWs. Two DO violations were observed from USGS data over a three year period. Average DO levels from JCHD1 and the USGS data were 8.2 mg/l and 9.0 mg/l, respectively. Values for BOD and COD were the highest observed in this survey although not substantially higher than at other sites. Undissociated H_2S Cd and Hg

concentrations were in violation of KSWs. The Cd value exceeded the U.S. EPA recommended acute protection criterion (EPA 1980c), while Pb exceeded the chronic protection criterion for aquatic life protection (EPA 1980d). The Cd and Pb concentrations were greater than mean values observed at JCHD1 and approached the maximum values seen at that site.

The SUD values for Fe and Mn were the highest observed in this study, although greater mean values for these parameters were observed at JCHD1 (Table 7). The USGS data at this site revealed two violations KSWs for Fe. The maximum values observed for Fe and Mn were 31,000 ug/l and 1,600 ug/l, respectively. Those values were noted during a period of high flow (1,810 cfs). The source of these metals is possibly soil erosion as a result of agricultural practices in the watershed. Oxides of Fe and Mn occur freely in soils (Hutchinson 1957), and high turbidity, due to agricultural siltation, has been observed in the upper half of Floyds Fork (OCSCD 1981). Values for other metals were within the range reported by JCHD and USGS.

Detectable quantities (2.2 ug/l) of 2,4-D, a phenoxy herbicide, were noted (May, 1980) by USGS, although values for other organic compounds were below detection limits. This level of 2,4-D does not appear to be toxic to aquatic life (refer to Johnson and Finley 1980). Phthalate esters were below detection limits.

Currys Fork

Station 28-2

This station is influenced by point source and nonpoint agricultural impacts. Values for most physicochemical parameters seem typical for agricultural watersheds draining limestone lithologies in the Blue Grass physiographic region (DOW ambient water quality data). Values for TP were nearly twice that observed at the other two stations in segment 28, possibly because of

the presence of point source dischargers (Table 2). This was reflected by the dense growths of periphyton noted. This abundance of filamentous algae partially explains the elevated DO and pH values observed at this station. Undissociated hydrogen sulfide and Hg levels were in violation of KSWS. The Cd concentration exceeded U.S. EPA recommended acute protection criteria levels (U.S. EPA 1980c), while Pb exceeded chronic protection criteria levels for aquatic life (U.S. EPA 1980d). Phthalate esters were below detection limits.

The sediments were heavily polluted with As and Pb and moderately polluted with Cd and Cr (U.S. EPA 1977). Detectable quantities of PCP (2.1 mg/kg) were present in the sediments, although values for other organic compounds were below detection limits.

North Fork Currys Fork

Station 28-3

This station exhibited elevated values for pH, conductivity, alkalinity, Cl^- , total hardness, $\text{SO}_4^{=}$, calcium (Ca), and magnesium (Mg) with respect to several SUD sites. Nutrient concentrations, notably $\text{NO}_2+\text{NO}_3\text{-N}$, were among the lowest seen in this survey. Despite those relatively low levels of nutrients, moderate to dense growths of attached algae were present, which partially explain the elevated DO and pH values (Table 4). Water column concentrations of most metals were relatively low and most likely represent background levels; however, Hg was in violation of KSWS and Cd was in excess of chronic protection criteria for aquatic life (U.S. EPA 1980c). Phthalate esters were below detection limits. Since this stream flows between the lanes of Interstate 71, there is a potential impact by certain metals, notably Pb, during wet weather periods. While water column values for Pb and As at 28-3 were the lowest observed during the SUD survey, the elevated sediment and water column values noted downstream (28-1, 28-2) may be the result of this type of impact. Heavy metal contamination of stream sediments

resulting from automotive traffic was discussed by Hassel et al. (1980), who observed low water column metal values in association with elevated sediment metal concentrations at sites adjacent to highways. Road de-icing salts during winter months creates a potential Cl^- impact (Scott 1980).

BIOLOGICAL EVALUATION

Biological data were collected and analyzed for the following groups of aquatic organisms: fecal coliform and fecal streptococci bacteria, algae, macroinvertebrates and fish. Site specific data were compared with other sites sampled in the survey, available historical data concerning the Floyds Fork drainage and appropriate scientific literature regarding the environmental requirements and tolerances of aquatic organisms. It was found that aquatic life in certain portions of the Floyds Fork system was adversely affected by WWTP effluents. Stream biota at these sites were limited to pollution tolerant forms. At less impacted sites, aquatic communities were dominated by facultative organisms; that is, stream species which exhibit a wide range of environmental tolerance.

No violations of KSWs criteria for fecal coliform bacteria (primary contact recreation) were observed during the SUD survey; however, these samples were not taken during the recreational season (May 1 -October 31). Data (USGS, JCHD) from various sites in the Floyds Fork system indicated frequent violations of primary contact criteria, while WQAB data indicated that primary contact bacterial criteria were being achieved during the recreational season. High bacterial levels often occur in conjunction with high flow (storm) events.

The Floyds Fork system contains a diversity of habitats which would allow an even greater diversity of aquatic organisms to exist in the absence of water pollution impacts. A total of 263 algal taxa (Appendix C) were encountered in the drainage, dominated by species characteristic of nutrient rich, highly oxygenated, flowing waters. Elevated water column nutrient concentrations have stimulated dense growths of filamentous algae which have created localized nuisances and concurrent degradations in water quality. Physiological stress was noted in several diatom species at sites known to be impacted by certain heavy metals.

A total of 139 taxa of aquatic macroinvertebrates (Appendix D) were collected from the drainage, with adverse impacts to the communities noted in and downstream of Chenoweth Run. A core of tolerant species consistently appeared at each site. Freshwater mussels were collected at all sites except Chenoweth Run, although recruitment was not apparent at any SUD site. A total of 18 mussel species were collected from the drainage, although 13 of these species were found only as relic shells.

A total of 46 fish species, (Appendix E) including numerous darter and minnow species, are known from the drainage. Although some areas of the stream appear to be organically enriched, the fish communities do not seem to be adversely affected. A sport fishery existed at all sites sampled. Tissue analysis of fish from station 27-1 indicated detectable levels of certain metals and organic compounds (Appendix F) although FDA action levels were not exceeded. The trout perch Percopsis omiscomaycus, listed by the Kentucky Nature Preserves Commission-Kentucky Academy of Science as being of special concern, was collected in the upper portion of the Floyds Fork system.

Based on the abundant habitat and diverse aquatic communities. Floyds Fork (segments 25, 26, 27 and 28) should be designated for Aquatic Life/Warmwater Aquatic Habitat per 401 KAR 5:031, Section 4 and the criteria listed applied throughout the drainage.

Bacteriology

Seven stations were sampled by DOW in 1981. No violations of KSWs (401 KAR 5:031, Section 6 (1)(a)) Fecal Coliform (FC), criteria for primary contact recreation occurred at the seven SUD stations (Table 9). There was one violation of the pH criterion (6.0 to 9.0) for recreation at station 26-1 on Chenoweth Run. Fecal coliform/fecal streptococci (FC/FS) ratios, which are indicators of the fecal pollution source (human or animal), were not applied because of low fecal streptococci levels found in analysis of samples at from each station (Table 9).

**Table 9: Summary of Bacteriological Results
Collected by the Division of Water in 1981 and 1982**

DIVISION OF WATER

Date	Station	Source Location	Fecal Coliforms per 100 ml	Fecal Streptococci per 100 ml	FC/FS
19/Nov/81	12025001	Floyds Fork	140	96	1.5
19/Nov/81	12025002	Floyds Fork	32	54	0.6
18/Nov/81	12026001	Chenoweth Run	130	54	2.4
18/Nov/81	12027001	Floyds Fork	K 2	10	
18/Nov/81	12028001	Floyds Fork	K 2	10	
18/Nov/81	12028002	Currys Fork	10	18	1.8
18/Nov/82	12028003	North Fork Currys Fork	220	80	2.7

DOW/USGS

Date	Station	Source and Location	Fecal Coliforms per 100 ml
28/Jul/82	03297845	Floyds Fork, Crestwood	610
20/Aug/82	03297845	Floyds Fork, Crestwood	510
3/Sept/82	03297845	Floyds Fork, Crestwood	1,000
26/Oct/82	03297845	Floyds Fork, Crestwood	32
18/Nov/82	03297845	Floyds Fork, Crestwood	240
10/Dec/82	03297845	Floyds Fork, Crestwood	62
15/Jul/82	03298000	Floyds Fork, Fisherville	250
16/Aug/82	03298000	Floyds Fork, Fisherville	420
2/Sept/82	03298000	Floyds Fork, Fisherville	1,600

WQAB

Date	Station	Source and Location	Fecal Coliforms per 100 ml
Oct. 81	WQAB1	Floyds Fork, Fisherville	510
Dec. 81		Floyds Fork, Fisherville	93,000
Apr. 82		Floyds Fork, Fisherville	450
July 82		Floyds Fork, Fisherville	130
Oct. 81	WQAB2	Floyds Fork, Bardstown Rd.	130
Dec. 81		Floyds Fork, Bardstown Rd.	21,000
Apr. 82		Floyds Fork, Bardstown Rd.	320
July 82		Floyds Fork, Bardstown Road	470

K = actual value less than value given

Of the two DOW/USGS joint stations sampled in 1982, there were five violations of the FC criteria for primary contact recreation in nine monthly samples (Table 9). However, FC levels at these two stations were nearer acceptable levels for primary contact recreation (400 FC colonies per 100 ml maximum) than secondary contact recreation levels (5,000 FC colonies per 100 ml maximum).

Using maximum recreational levels without regard to season (Table 10), of the six stations monitored by JCHD from 1975 to 1982 on Floyds Fork, Cedar Creek (JCHD5) and Pennsylvania Run (JCHD6), primary contact recreation FC criteria were violated in 46% of 343 samples. Secondary contact FC criteria were violated in 9% of all samples. Jefferson County Health Department maximum and minimum values for all years indicated extreme fluctuations in FC levels at all stations (Table 11). Fecal coliform/fecal streptococci (FC/FS) ratios indicated the fecal pollution to be animal in origin from both human and animal sources at JCHD5, JCHD5 and JCHD6, while JCHD1, JCHD2 and JCHD3. The source of animal fecal pollution is most likely from stormwater runoff. The probable sources for the human fecal pollution are (1) improperly operating sewage treatment plants and (2) septic tank infiltration into the Floyds Fork system.

DOW compliance sampling inspections of certain dischargers within the basin (Table 12) indicated FC levels in the treated effluents meet NPDES permit requirements, with the exception of Ash Avenue Sewer Company. Fecal coliform levels of that plant's effluent showed consistently high FC levels (Table 12). A lift station associated with the Ash Avenue Sewer Company has bypassed raw sewage to an unnamed tributary to Floyds Fork at MP 44.3. That company has been involved in litigation for several years (DOW files). Ash Avenue Sewer Company represents a known threat to public health and primary contact recreation within the Floyds Fork system.

**Table 10: Fecal Coliform Standards
Violations Applied to All Seasons**

STATIONS	SOURCE	OBSERVATIONS	PRIMARY CONTACT VIOLATIONS		SECONDARY CONTACT VIOLATIONS	
<u>DIVISION OF WATER</u>						
		No.	No.	%	No.	%
12025001	Floyds Fork	1	0	0	0	0
12025002	Floyds Fork	1	0	0	0	0
12026001	Chenoweth Run	1	0	0	0	0
12027001	Floyds Fork	1	0	0	0	0
12028001	Floyds Fork	1	0	0	0	0
12028002	Currys Fork	1	0	0	0	0
12028003	N. F. Currys Fork	1	0	0	0	0
<u>DOW/USGS</u>						
03297845	Floyds Fork	6	3	50	0	0
03298000	Floyds Fork	3	2	67	0	0
<u>JCHD</u>						
JCHD-1	Floyds Fork	57	26	46	6	11
JCHD-2	Floyds Fork	57	25	44	6	11
JCHD-3	Floyds Fork	58	31	53	13	22
JCHD-4	Floyds Fork	57	30	53	5	9
JCHD-5	Cedar Creek	57	21	37	2	4
JCHD-6	Pennsylvania Run	57	24	42	1	2
<u>WQAB</u>						
WQAB-1	Floyds Fork	4	3	75	1	25
WQAB-2	Floyds Fork	4	2	50	1	25

**Table 11: Fecal Coliform Data Summary
Jefferson County Health Department Sampling
(no./100ml)**

<u>1975-82</u>	<u>Site</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>
JCHD-1	Floyds Fork	L200,000	9	1800
JCHD-2	Floyds Fork	50,000	K9	3500
JCHD-3	Floyds Fork	40,000	K9	4000
JCHD-4	Floyds Fork	L200,000	K9	1578
JCHD-5	Cedar Creek	22,000	K9	1200
JCHD-6	Pennsylvania Run	8,800	K9	780

**Jefferson County Health Department Sampling Stations
During Recreation Season (May through October)**

<u>1975-82</u>	<u>Site</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>
JCHD-1	Floyds Fork	L200,000	9	1250
JCHD-2	Floyds Fork	50,000	9	3400
JCHD-3	Floyds Fork	40,000	9	4000
JCHD-4	Floyds Fork	L200,000	10	2100
JCHD-5	Cedar Creek	22,000	K9	1900
JCHD-6	Pennsylvania Run	8,800	40	1000

K = actual value less than value given
L = actual value greater than value given

**Table 12: Division Of Water
Compliance Sampling Inspection
Bacteriological Data**

<u>Date</u>	<u>Facility</u>	<u>Receiving Stream</u>	<u>Fecal Coliforms per 100 ml</u>
14/Apr/82	Maryville #2 Subdivision	U.T. to Brooks Run	16
27/Sept/79	Jeffersontown WWT	Chenoweth Run	10
14/Jul/82	Jeffersontown WWT	Chenoweth Run	150
19/Jun/80	Jeffersontown WWT	Chenoweth Run	590
11/Mar/80	Idlewood Subdivision	Cedar Creek	K 1
21/Apr/82	Idlewood Subdivision	Cedar Creek	K 2
29/Jul/80	Ash Ave Sewer Co.	U.T. to Floyds Fork	L8,000
1/Jul/81	Ash Ave Sewer Co.	U.T. to Floyds Fork	500,000
2/Mar/83	Ash Ave Sewer Co.	U.T. to Floyds Fork	L16,000

K = actual value less than value given

L = actual value greater than value given

With the exception of Pennsylvania Run (JCHD6), mean FC levels at all JCHD stations from 1975 through 1982 were nearer to levels acceptable for secondary contact recreation than to primary contact recreation levels (Table 10). The WQAB monitored two stations on Floyds Fork, collecting four seasonal samples (Table 9) (1981-1982). Those samples indicated primary contact recreation FC levels were being achieved or were attainable at these stations during the recreational season (Tables 11, 12, 13). Only winter samples showed unacceptable FC levels for secondary contact recreation. Sampling by DOW showed acceptable FC levels for primary contact recreation, but sample collection occurred in November, 1981 and not during the recreation season (May 1 - October 31).

Fecal coliform criteria were violated in approximately 60% of all samples collected during the primary contact recreation season (May 1 through October 31). Of those samples, approximately 11% failed to meet the secondary contact recreation FC criterion (Table 13). For primary contact recreation criteria to be attained, monitoring the discharges to Floyds Fork during the recreation season and compliance of permitted discharges with their NPDES permit is a necessity.

Algae

The Floyds Fork system supports a very diverse algal community (Appendix C), with a total of 263 taxa encountered during this study. Most species encountered were typical stream forms that exhibit a wide range of environmental tolerance. Species richness, diversity (\bar{d}) and equitability (e) were variable (Table 14). Species richness was highest at stations 27-1 and 28-2, while \bar{d} and e were highest at station 25-1. Algal community structure and dominant taxa were different at each site as a result of variations in water quality, substrate, flow and physiographic characteristics. All sites sampled were dominated by taxa associated with nutrient-rich conditions. Nutrient enrichment from both point and nonpoint sources has resulted in localized, dense attached algal growths. This

**Table 13: Fecal Coliform Standards Violations
During Recreation Season (May-October)**

STATIONS	SOURCE	OBSERVATIONS	PRIMARY CONTACT VIOLATIONS %		SECONDARY CONTACT VIOLATIONS	
		No.	No.	%	No.	%
<u>DOW/USGS</u>						
03297845	Floyds Fork	4	3	75	0	0
03298000	Floyds Fork	3	2	67	0	0
 <u>JCHD</u>						
JCHD-1	Floyds Fork	32	17	53	4	12
JCHD-2	Floyds Fork	34	17	50	4	12
JCHD-3	Floyds Fork	35	22	63	7	20
JCHD-4	Floyds Fork	35	20	57	4	12
JCHD-5	Cedar Creek	32	20	61	2	6
JCHD-6	Pennsylvania Run	34	24	44	1	3
 <u>WQAB</u>						
WQAB-1	Floyds Fork	2	1	50	0	0
WQAB-2	Floyds Fork	2	1	50	0	0

Table 14: Total Taxa, Diversity (d), Equitability (e), Chlorophyll-a and Ash-free Dry Weight for the Floyds Fork System at Stations 25-1 through 28-3.

<u>Station</u>	<u>25-1</u>	<u>25-2</u>	<u>26-1</u>	<u>27-1</u>	<u>28-1</u>	<u>28-2</u>	<u>28-3</u>
Total Taxa	123	121	132	153	114	152	90
Diversity (d)	5.1333	3.3750	3.5283	4.3849	4.0970	3.5068	2.6904
Equitability (e)	0.5149	0.1666	0.2073	0.2672	0.2809	0.1633	0.1200
Chlorophyll-a (mg/m ²)	0.953*	7.877	1.297*	1.257	12.799	4.458	1.016*
Ash-free Dry Weight (g/m ²)	0.4325*	1.2401	0.2638*	0.1055	1.0466	0.9499	0.1759*

*Periphytometer covered with debris at the time of collection - values most likely higher than indicated.

Total Taxa Encountered in Study: 263

phenomenon is generally supported by chlorophyll-a and AFDW data; however, because of a storm event during the exposure period, several periphytometers were partially covered with debris. While the results from these affected samplers are presented in this report, the values observed are most likely lower than expected. A total of 18 new diatom collection records for Kentucky were noted in the Floyds Fork drainage.

Since sufficient habitat and water quality currently exists to maintain a diverse lotic algal community, it is recommended that the entire drainage be classified as warmwater aquatic habitat. It should be recognized that certain stream segments (notably 25 and 26) are currently under stress from point and nonpoint source impacts. Additional impacts, i.e. increased development in the watershed, to the Floyds Fork system may adversely affect algal communities in these streams.

Floyds Fork

Station 25-1

This site was characterized by moderate amounts of filamentous species including green and red algae, as well as the diatom Melosira varians. The red alga Audouinella, which was absent from algal communities at upstream stations (25-2, 26-1), was well represented at this site, suggesting improved water quality. Placoderm desmids were also common, as were planktonic green and blue-green algal species (Appendix C). The source of these eutrophic planktonic species is possibly McNeely Lake, which is approximately 13 miles upstream from this station.

Most of the algal community consisted of alkaliphilous (commonly found at pH concentrations greater than 7.0) taxa associated with moderate nutrient enrichment. While species richness was similar to that observed at the upstream site (25-2), the dominance of diatoms and green algae here, as well as a reduction of filamentous blue-green algae from that seen at 25-2, indicates improved water

quality. Chlorophyll-a and ash-free dry weight (AFDW) values (Table 14) were in the unproductive range (DOW 1981a); however, the sampler was covered with debris at the time of collection. Chlorophyll-a and AFDW values are most likely higher than indicated by these samples.

The diatom community consisted largely of a diverse assemblage of typical stream species associated with nutrient enrichment and elevated conductivity levels (Appendix C). Diatom d and e were the highest observed in this study (Table 14). This largely results from improved water quality at this site, but also reflects the presence of uncommon species. For example, occurrences of Bacillaria paradoxa (2.6% relative abundance), Amphipleura pellucida and Eunotia incisa are unusual in this part of the state. These species are more common in eastern Kentucky. Their presence at this site may result from physiographic differences, since Floyds Fork enters the Knobs region near this station. The presence of Amphora veneta, Navicula texana and Synedra incisa at this and other sites in the drainage represent new collection records for Kentucky (refer to Camburn 1982). The diversity noted in epipelic (associated with sediments) taxa suggests siltation impacts from land disturbance activities.

Floyds Fork

Station 25-2

The algal community was dominated by dense growths of filamentous green and blue-green algae characteristic of nutrient enrichment. Cladophora glomerata and Stigeoclonium lubricum were the dominant filamentous species. Dense growths of Cladophora are generally found in waters with high nutrient concentrations, while Stigeoclonium not only indicates nutrient enrichment (Palmer 1977), but is also known to tolerate heavy metals (Patrick 1978). Planktonic blue-green and green algae (Order Chlorococcales) were abundant and diverse. These species are common in eutrophic, hardwater lakes (Prescott 1962, Palmer 1977).

Planktonic species are generally not common in streams. Their occurrence at this site and at station 26-1 is most likely the result of numerous ponds and small lakes present in the Chenoweth Run watershed. The combination of abundant filamentous algae and small planktonic forms provides excellent habitat and food for aquatic macroinvertebrates and fish. However, dense filamentous algal growths are often considered an aesthetic nuisance and may cause localized water quality problems when algal filaments break loose from the substrate, collect in pool areas and decay. Periphyton chlorophyll-a values were in the very productive range ($> 4 \text{ mg/m}^2$) (DOW 1981a) and AFDW values were typical of productive streams (Table 14).

The diatom community was dominated by alkaliphilous species generally found in waters of high nutrient content (Patrick and Reimer 1966, Lowe 1974). The most abundant species were those which are typically observed as epiphytes of Cladophora (Lowe 1974), the dominant filamentous alga at this station. The occurrence of halophilic (salt-loving) taxa, such as Nitzschia filiformis (11.9% relative abundance) and Cyclotella meneghiniana (3.6%), reflects the elevated chloride levels at this site. Nitrogen heterotrophic species were also well represented in the community. Heterotrophic diatoms require nitrogenous organic compounds for abundant growth and can utilize these substances as an energy source in lieu of sunlight (Hellebust and Lewin 1977). These species have a competitive advantage in water impacted by sewage effluents containing elevated levels of nitrogenous compounds.

Diatom \bar{d} was typical for the drainage, but \bar{e} was low because of the dominance of certain species discussed previously (Table 14). Despite physicochemical impacts at this station, \bar{d} and species richness were good, with an abundance of typical stream forms and tolerant species. The presence of Achnanthes hauckiana, Cymatopleura elliptica var. constricta, Navicula

mucicoloides, Neidium dubium var. productum, and Nitzschia inconspicua, at this and other sites in the drainage, represent new collection records for Kentucky (refer to Camburn 1982).

Chenoweth Run

Station 26-1

Chenoweth Run was dominated by dense growths of filamentous and encrusting green and blue-green algae, as well as tolerant diatoms. Stigeoclonium lubricum was abundant in riffle areas. This filamentous green alga indicates nutrient enrichment (Palmer 1977) and tolerates elevated concentrations of heavy metals (Patrick 1978). Planktonic blue-green, green (Chlorococcales) and euglenoid algae were also very common. These taxa are typically found in eutrophic, hardwater lakes (Prescott 1962; Palmer 1977). The ecological implications of these planktonic algae has been discussed previously (25-2). The algal community at this site is typical of nutrient enriched waters. While chlorophyll-a and AFDW values were low (Table 14) because of debris accumulation on the periphytometer, DO and pH values were very high, which is often observed in streams containing dense growths of algae (Warren 1971; DOW unpublished data). Species richness was above average for the Floyds Fork system, because of the presence of typical stream forms which exhibit a wide range of environmental tolerance, as well as species associated with certain constituents of WWTP effluents (e.g. metals, salts, amino acids, etc.).

The diatom community was dominated by Amphora veneta (41.5% relative abundance) (Appendix C), a species previously unreported from Kentucky. This is an alkaliphilous diatom which tolerates a wide range of Cl^- concentrations (Lowe 1974) and grows most abundantly at pH concentrations greater than 8.5 (Cholnoky 1968). The Cl^- concentration at this station was the highest observed in the survey (57.7 mg/l) and the field pH was 9.2. Frustular aberrancy, i.e.

physiological stress, was noted in many individuals of this species. Frustular aberrancy (C. Reimer, pers. comm.), is often seen in conjunction with elevated levels of heavy metals (DOW 1981b; DOW 1983). Sediment concentrations of metals were elevated at this site (Table 5), particularly for Cu, Pb, and Zn.

Nitrogen heterotrophic and halophilic taxa were abundant in the community. The association between nitrogen heterotrophs and sewage effluents has been discussed previously. Halophilic species are those in which growth is stimulated by dissolved salts, notably NaCl (Lowe 1974). Halophilic taxa are common in streams impacted by WWTP effluents because of elevated levels of Cl^- in these effluents (Hynes 1974), as well as in streams impacted by oil brine (DOW 1982).

Diatom \bar{d} and e were typical for the Floyds Fork system (Table 14). Equitability values were low, because of the dominance of certain species discussed earlier. The occurrence of Pinnularia abaujensis var. linearis at this site represents a new collection record for Kentucky (refer to Camburn 1982).

Floyds Fork

Station 27-1

This station was characterized by relatively sparse growths of attached algae and dominated by filamentous green algae and pennate diatoms. Blue-green algae were poorly represented. However, the algal community was very diverse, particularly diatoms and green algae of the order Chlorococcales (Appendix C). This latter taxon consisted mainly of planktonic forms characteristic of nutrient enriched water (Palmer 1977), although nutrient values at this site were among the lowest observed in this study. Most of the community consisted of alkaliphilous taxa associated with moderate to elevated conductivity levels, although certain species in the community are associated with slightly acidic waters of low mineral content (Patrick and Reimer 1966, 1972, Lowe 1974). Chlorophyll-a values were in

the unproductive range ($< 1.5 \text{ mg/m}^2$) (DOW 1981a), as were AFDW values.

The diatom community consisted of a diverse assemblage of largely typical stream forms. Diatom \bar{d} was among the highest observed in the drainage (Table 14). Equitability values were low, a result of the dominance (39% relative abundance) of Cocconeis species, common epiphytes of Cladophora. Aberrant frustular morphology was noted in Cymbella affinis, indicating physiological stress (C. Reimer, pers. comm.) and elevated concentrations of heavy metals (DOW 1981b; DOW 1983). Water column values for metals, notably Pb and Al were elevated compared to some other Floyds Fork sites (Figure 3). The presence of taxa characteristic of different environmental conditions, plus the abundance of aerophilic species (characteristic of springs and seeps), suggests a great deal of variability in water quality conditions. The occurrence of Caloneis ventricosa var. alpina, Epithemia sorex, Fragillaria capucina var. mesolepta, Navicula mutica var. undulata, Navicula tenera, and Nitzschia chasei, at this and other sites in the drainage, represent new collection records for Kentucky (refer to Camburn 1982).

Floyds Fork

Station 28-1

The algal community was dominated by moderate growths of filamentous green and blue-green algae, as well as pennate diatoms. Motile algae representative of four algal divisions were also common at this station (Appendix C). Non-filamentous green algae (particularly Chlorococcales) were poorly represented. Chlorophyll-a values were in the very productive range ($> 4 \text{ mg/m}^2$) and were the highest observed in the drainage (Table 14). In contrast, AFDW values were not particularly elevated compared to other sites in the Floyds Fork drainage. This suggests that the biomass generated by primary producers largely consists of autotrophic organisms (algae), with lesser influence by heterotrophic organisms such as bacteria and protozoans. The algal community consisted mainly

of typical stream taxa, with some influence by species associated with moderate nutrient enrichment. Many of the algal filaments collected at this site appeared to be stained a golden-brown color, possibly reflecting the elevated Fe concentrations noted in water column samples (Table 4). Species richness was considerably less than seen at 28-2 and 27-1, although d and e here were intermediate between those stations.

The diatom community was dominated by typical stream forms which are tolerant to a wide range of water quality conditions. Certain commonly occurring taxa suggest nutrient and sedimentation impacts, most likely from nonpoint agricultural runoff. A number of species associated with elevated conductivity were present in the community. The community was productive and diverse with no aberrant forms noted. The occurrence of Navicula capitata var. hungarica and Navicula cincta, at this and other sites in the drainage, represent new collection records for Kentucky (refer to Camburn 1982).

Currys Fork

Station 28-2

This station was characterized by dense growths of filamentous green, blue-green, and red algae. The algal community was very diverse, particularly placoderm desmids and members of the green algal order Chlorococcales. Many planktonic species were noted in the community, reflecting the influence of numerous ponds and small lakes in the upstream watershed. The presence of these planktonic forms partially explains the abundance of taxa (152). Chlorophyll-a and AFDW values (Table 14) were in the productive range although somewhat lower than might be predicted given the dense growths of filamentous algae noted at this site. The algal community consisted of typical stream species characteristic of nutrient enrichment, as well as taxa associated with soils, suggesting nonpoint agricultural impacts.

The diatom community was dominated by Cocconeis species (66%), which are common epiphytes of Cladophora, an abundant taxon at this site. The dominance of Cocconeis explains the relatively low \bar{d} and \bar{e} values observed. The diatom community consisted of alkaliphilous taxa characteristic of moderate nutrient, conductivity, and salinity levels (Patrick and Reimer 1966, 1972, Lowe 1974). Many commonly occurring species are typical rheophilic (flowing water) forms associated with highly oxygenated waters. The occurrence of Fragillaria pinnata var. lancettula represents a new collection record for Kentucky (refer to Camburn 1982).

North Fork Currys Fork

Station 28-3

The algal community was dominated by moderate to dense growths of filamentous blue-green and green algae. Non-filamentous algae, exclusive of diatoms, were poorly represented. The community contained the lowest number of taxa observed in this survey (Table 14). Likewise, \bar{d} and \bar{e} were the lowest seen in the drainage, probably related more to stream order, substrate, and microhabitat differences than to water quality limitations. Chlorophyll-a and AFDW values were in the unproductive range, however, the sampler was covered with debris at the time of collection. Chlorophyll and biomass values are most likely higher than indicated by these samples, particularly in light of the dense growths of filamentous algae noted previously. The algal community consisted of alkaliphilous taxa typical of small, well oxygenated streams (Lowe 1974). Influence by planktonic organisms was minimal.

The diatom community was diverse (Appendix C) and dominated (72%) by Cocconeis, a typical stream taxon associated with Cladophora, which accounts for the low \bar{d} and \bar{e} values observed. This same phenomenon was noted at other sites in the drainage. The community was composed of typical rheophilic stream

species associated with nutrient enrichment and slightly elevated conductivity and salinity levels.

Macroinvertebrates

The benthic communities collected from the Floyds Fork system contained all the functional feeding groups designated by Merritt and Cummins (1978), Vannote et al. (1980) and Hawkins and Sedell (1981). Since the various functional feeding groups serve as components of the invertebrate community structure, the analysis of those groups provides essential information for the assessment of communities and, consequently, enhances the interpretation of stream uses and water quality.

In spite of past and present impacts to the stream system, the invertebrate communities express an appreciable resiliency (Appendix D). For instance, the occurrence of freshwater mussels, at each station except 26-1 (Chenoweth Run), is significant in relation to past and present water quality because of their relatively long life cycles and close affinities to the water column and substrate. Taylor (1980) surveyed the mussel fauna of Floyds Fork and collected 18 species. Many of those were relic shells. Collections from this survey yielded live specimens of five species, while relic shells accounted for another 13 species. Recruitment of young mussels was not apparent at any collection site. Based on those observations, it is concluded that the mussel fauna has been reduced in species composition and presently consists primarily of species associated with headwater habitats.

Collections from 26-1 show a reduction in numbers of species and a difference in species composition from other stations in the drainage. That peculiar community structure is attributed to elevated nutrients as well as certain metals and organics present in the water column and sediments. The macroinvertebrate communities at each station were dominated by facultative

organisms, with slight differences in species composition from headwaters to lower reaches. A core of tolerant species was consistently present at each station.

Floyds Fork

Station 25-1

Extensive habitats for macroinvertebrates were present at this site. The most abundant habitats were associated with the large surface areas provided by the flat limestone rocks in the riffles. The organisms preferring those habitats were most diverse in feeding types. Other physical stream characteristics, such as width, flow volume and canopy, contributed to an appreciably higher taxa richness within all functional groups compared to that seen at upstream stations.

In the quantitative collections, the relative abundance percentages were numerically dominated by filterer organisms (Appendix D). This station had the most abundant mussel habitat of any station; however, after extensive sampling live specimens of only two species were collected. Relic shells accounted for an additional 15 species. Apparently, little or no recruitment of young mussels is occurring in this portion of the stream.

Floyds Fork

Station 25-2

The habitats at this site were associated with the bedrock limestone and steep undercut banks, as well as a diversity of other habitats along the upper reaches of the site. This variety of available habitats is responsible for the excellent diversity and composition of organisms occurring there (Appendix D). The collector and the scraper organisms were the most numerous functional feeding groups in the qualitative collections. However, filterer organisms dominated the quantitative collections in composition and numbers (Appendix D). The occurrence of tolerant organisms in large numbers is not unexpected when considering the impacts from the immediate upstream station (26-1). In spite of

exhaustive collecting time and ample habitat, only one species of mussel was collected. Relic shells accounted for three other species.

Chenoweth Run

Station 26-1

Analysis of the functional feeding groups at this site shows the benthic community was lower in numbers and different in species composition than all other sites in the drainage. The most obvious reason for that disparity is expressed in the sediment data, which showed many of the highest metal values recorded in the drainage (Table 5). Secondly, the abundant growths of filamentous algae resulting from nutrient enrichment have eliminated or severely restricted the available habitats for many members of the benthic macroinvertebrate community. Those impacts are reflected in the quantitative collections. Collector and filterer organisms whose habitat and food requirements are not affected by algae constitute the highest percentages in those collections. However, organisms that depend upon certain substrate characteristics to satisfy habitat and food requirements were eliminated or severely reduced in the community. The macroinvertebrate community was dominated by tolerant organisms.

Floyds Fork

Station 27-1

The primary habitat at this site consisted of bedrock limestone and limestone pieces of all sizes that had been arranged and compacted by flow to form small, braided riffles. That particular substrate composition provides ample surface area for periphyton colonization, which in turn is conducive to scraper, filterer and collector organisms. The benthic community reflects a diversity of organisms within those functional feeding groups (Appendix D). The community consisted primarily of facultative organisms. A core of tolerant taxa which occurred consistently throughout the drainage dominated most of the functional

groups. The mussel fauna collected from this site appears to be typical of headwater habitats. The mussel composition found here is similar to that reported by Taylor (1980) at equivalent sites in the Floyds Fork drainage.

Floyds Fork

Station 28-1

This station was located in a reach that contained extensive pool areas connected by small braided riffles. The substrate in the riffles was composed of limestone rocks of all sizes. A difference existed in the species composition and the dominant functional groups of this site from that observed at other stations. The quantitative collections were dominated by coleopterans (beetles), ephemeropterans (mayflies), and the caddisfly Cheumatopsyche (Appendix D). Perhaps the substrate composition and other physical characteristics of the site were responsible for the composition of species. Three genera of mussels were collected and many relic shells were observed in depositional areas immediately upstream of the collection site.

Currys Fork

Station 28-2

The available habitats are largely those associated with headwater streams, such as small riffles and shallow pools. The benthic community structure is a reflection of those habitats, as shown by the quantitative collections (Appendix D). A single species of caddisfly, Cheumatopsyche, made up 37% of the total number of individual collected. Other species in the community were rather evenly distributed between filterer and collector groups. A single species of mussel, Anodonta grandis, was collected from the limited habitat of this site.

North Fork Currys Fork

Station 28-3

The available habitats for benthic organisms were largely composed of bedrock limestone, with pieces of chert, limestone and shale of all sizes in the

riffles. Nutrient enrichment was suggested by the dense growths of algae. In the quantitative collections, most of the functional groups reflected greater taxonomic richness than was noted at other sites in this segment (Appendix D). That richness was apparently related to the availability of food and habitats. The most numerous organism in the quantitative collections (52% of total individuals) was Psephenus herricki, a riffle beetle. Evidently, our collections coincided with the time for larval abundance of that invertebrate. Two species of mussels, both of which are associated with headwater streams, were observed.

Fish

Floyds Fork supports a diverse ichthyofauna, which reflects the diversity of habitats throughout the system. Thirty-seven species of fishes from 22 genera and nine families were collected during this survey (Appendix E). Some areas of the basin have been surveyed by the Kentucky Department of Fish and Wildlife Resources. Their collections added nine species to the total known from the drainage (Axon et al. 1982 and Henley 1983). Sport fish included bass (largemouth, spotted and rock), bluegill and redear sunfish. The sport fishing potential of most areas appears to be good (Sehlinger and Underwood 1980). In addition, 12 species of minnows and seven species of darters were collected. The trout-perch Percopsis omiscomaycus, a species which is listed by the Kentucky Nature Preserves Commission-Kentucky Academy of Science as being of special concern (Branson et al. 1981), was collected at one site and probably is present at other locations. The northern edge of Kentucky represents the periphery of the range of this northern species (Lee et al. 1980). The collection of the banded darter Etheostoma zonale at three locations apparently represents the first record for the Floyds Fork subbasin (refer to Clay 1975, Henley 1983). Although some areas of the stream appear to be organically enriched, the fish communities do not seem to be adversely affected.

Floyds Fork

Station 25-1

Fourteen species representing six families and a total of 67 individuals were collected (Appendix E). Mimic shiners Notropis volucellus and bluntnose minnows Pimephales notatus were the most abundant species. Two species of sunfish (rock bass Ambloplites rupestris and longear Lepomis megalotis) and three species of darters were collected. Included in the collection were five species which are considered somewhat intolerant of pollution, but none were present in large numbers. Based on this collection, the fish community IBI would be rated as fair.

Floyds Fork

Station 25-2

Twenty-three species representing seven families and a total of 290 individuals were collected. The most numerous species was the stoneroller Campostoma anomalum, which is not surprising because of the large areas of algae-covered bedrock on which this fish grazes. Another common species was the suckermouth minnow Phenacobius mirabilis, which also prefers organically rich streams (Smith 1979). Both species are intolerant of silt (Smith 1979). Bluntnose minnows Pimephales notatus were also abundant.

Five species of sunfish, including some specimens of game fish, were taken (Appendix E). Captured and released were: an 8 inch rock bass Ambloplites rupestris, a 10 inch largemouth bass Micropterus salmoides and a 12 inch spotted bass Micropterus punctulatus. Five species of darters, of which fantails Etheostoma flabellare and rainbows E. caeruleum were the most common, were collected in the riffle areas. Based on analysis of available data, the IBI would be rated as good to excellent.

Chenoweth Run

Station 26-1

Nineteen species from five families and a total of 138 individuals were collected (Appendix E). Nine species of cyprinids were taken, with stonerollers and bluntnose minnows being the most abundant. In addition, a large population of longear sunfish Lepomis megalotis was present, along with substantial numbers of bluegill L. macrochirus and green sunfish L. cyanellus. Only three species of darters were found, but none in great numbers. Most of the species found here are tolerant of organic enrichment (Smith 1979, DOW unpublished data). Based on present data, the IBI would be assessed as fair to good.

Floyds Fork

Station 27-1

Twenty-two species of fishes representing seven families and a total of 296 individuals were captured (Appendix E). The most abundant species were rainbow darters, striped shiners Notropis chrysocephalus and rosefin shiners N. ardens. Game species included bluegill, rock bass, largemouth bass and spotted bass. This was also the only site where the grass pickerel Esox americanus vermiculatus was taken in this survey. The high species diversity, high numbers of individuals and presence of five intolerant species rate the fish community IBI as good to excellent. One rock bass was collected at 27-1 for tissue analysis (Appendix F). Food and Drug Administration action level guidelines for chemical contamination in fish were not exceeded by any parameter.

Floyds Fork

Station 28-1

Twenty-one species of fish representing six families and a total of 201 individuals were collected (Appendix E). The most abundant species were bluntnose minnows and fantail darters. Other common species were golden redhorse, rosefin

shiner, johnny darter, bluegill and longear sunfish. Game species included sunfishes and spotted bass. Based on species diversity, numbers and the presence of three intolerant species, the fish community IBI is rated as good.

Currys Fork

Station 28-2

Nineteen species of fish representing seven families and a total of 195 individuals were collected (Appendix E). The most abundant species were rosefin shiners and bluntnose minnows. Rainbow and faintail darters were also common. Specimens of the trout perch Percopsis omiscomaycus, a species listed by the Kentucky Nature Preserves Commission-Kentucky Academy of Science as being of special concern (Branson et al. 1981), were collected. The northern part of Kentucky is the periphery of the range for this northern species (Lee et al. 1980). The fish community IBI is rated as fair to good.

North Fork Currys Fork

Station 28-3

Nineteen species of fish representing five families and a total of 257 individuals were collected (Appendix E). Stonerollers and bluntnose minnows were the most abundant, with creek chubs common. These species are typical headwater forms. This was the only station where redear sunfish Lepomis microlophus were collected. Game fishes included sunfishes and largemouth bass. The fish community IBI at this site is rated as good considering the size of the stream.